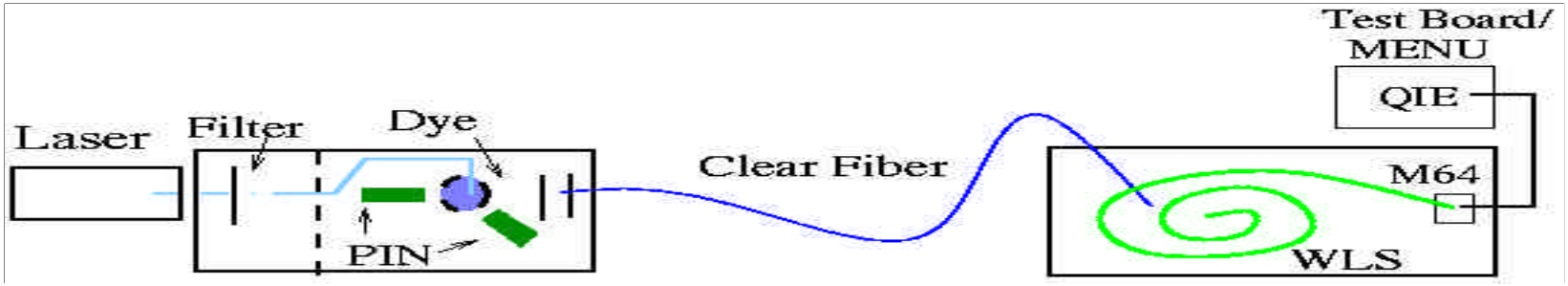
QIE Studies with an M64 PMT and a Scintillation Light Pulse

QIE Studies

- Nicolai Tobien, P.S.
- Single photo-electron response
  - Clock edge issues
- Pulse shape
  - Reflections? Variation with pulse height
    - Input impedance varied with pulse height on pre-MINOS QIEs
- Linearity
  - DC Charge injection calibration
  - Clock Edge Issues

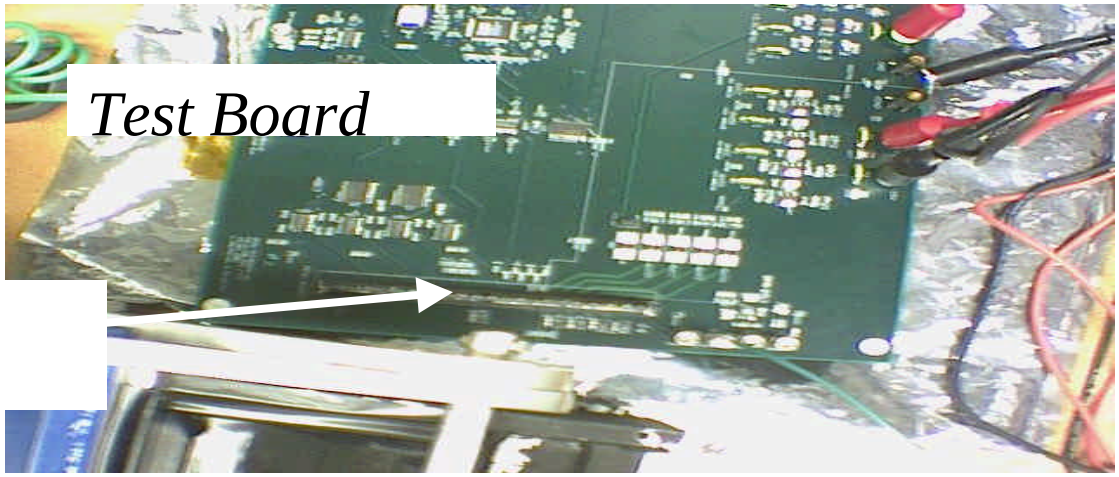
Lab 5 Test Stand

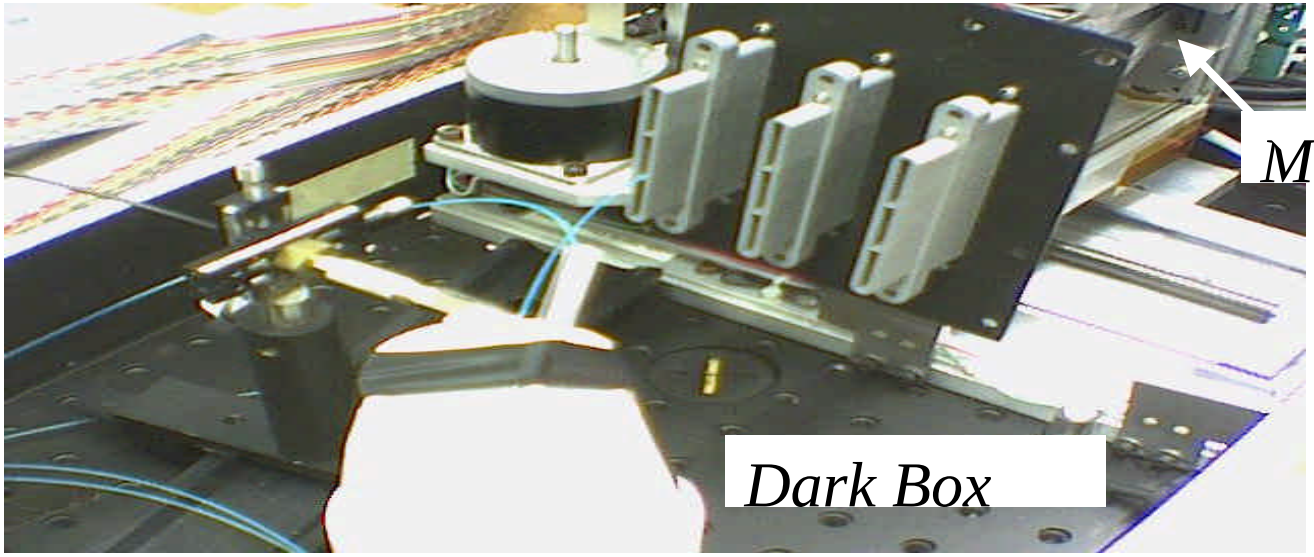
- General purpose test stand
  - Adapted for MINOS requirements



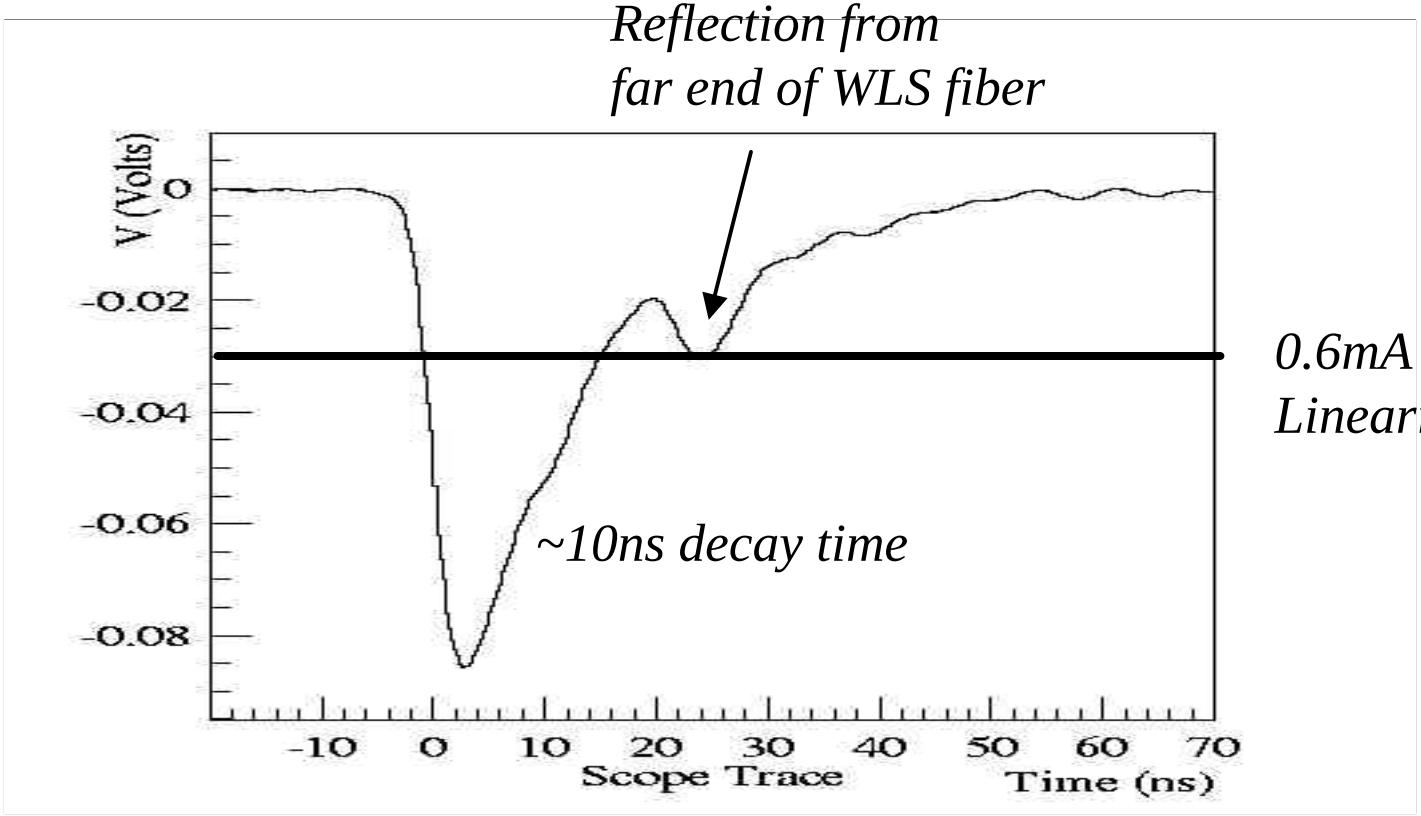
  - POPOP (one of 2 flours in MINOS scintillator) solution excited by Nitrogen laser
  - POPOP flourescence fed to 4 m WLS fiber
  - PIN Diodes with 20-bit DDC101 ADCs

Lab 5 Test Stand





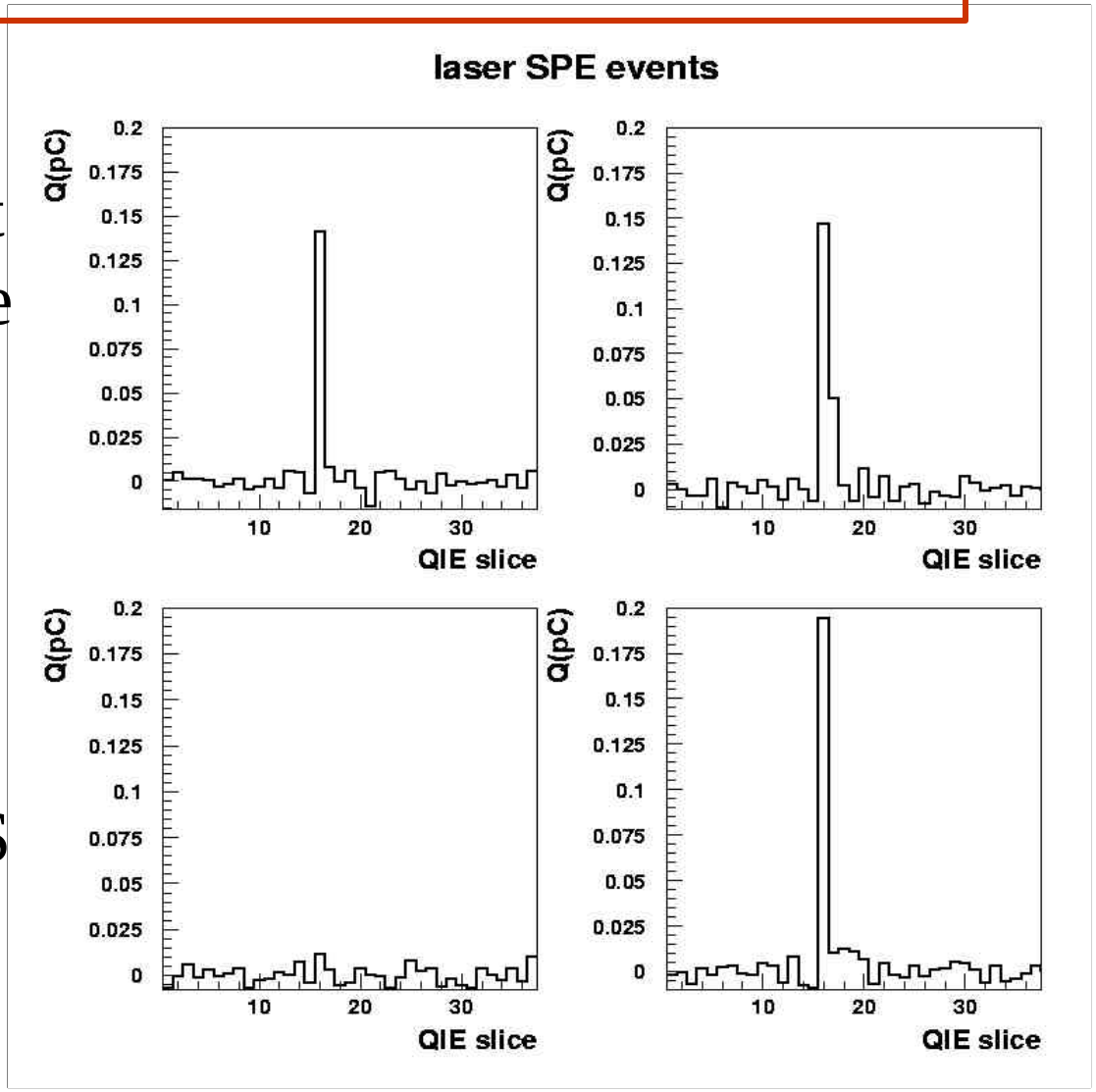
PMT Pulse



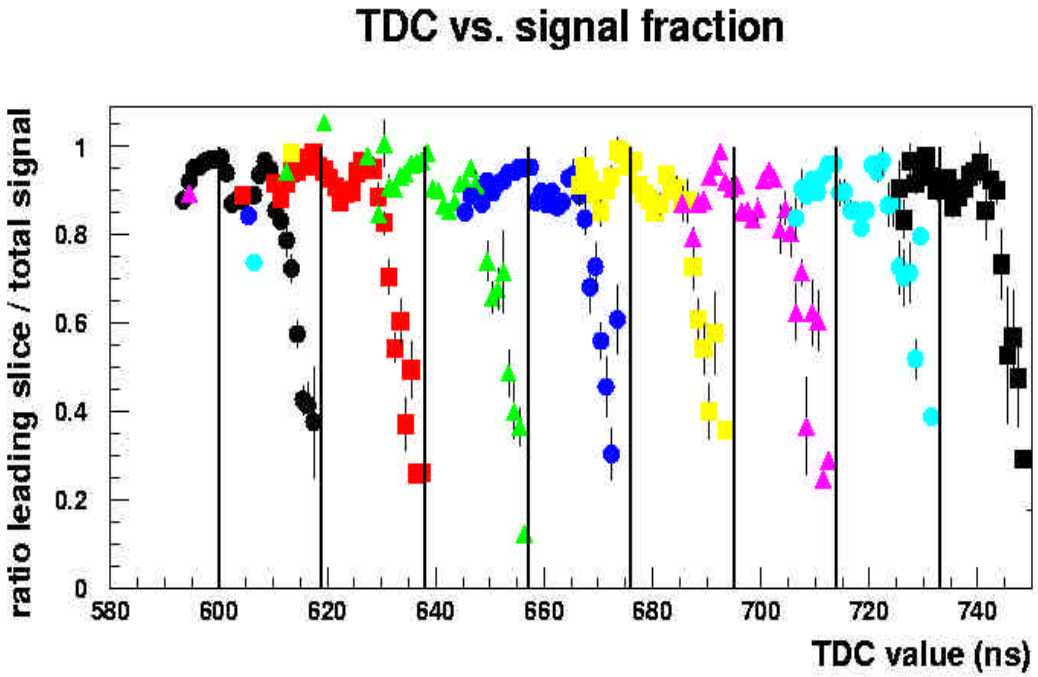
(This is a big pulse!)

Single Photo Electron Studies

- SPEs near clock edge may fall below readout threshold due to charge divided between RF slices.
  - Does QIE circuitry contribute to this?
- Use laser with no WLS to give good timing on SPEs

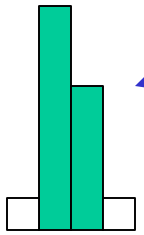


Studies of SPE Response



Fraction of charge in a single slice –

- Smaller fraction for events near clock edge



Fraction near 50%

Laser TDC allows identification of'

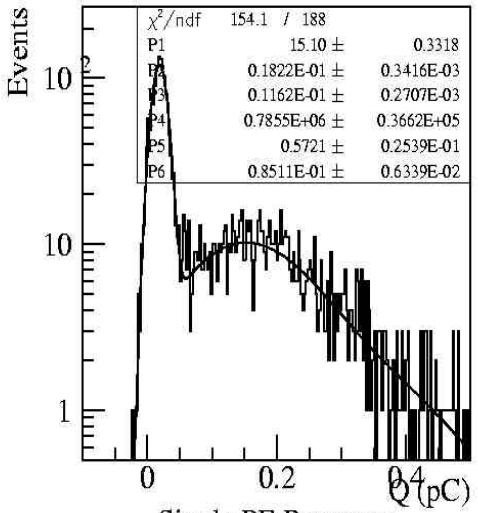
- RF slice of photo-electron
- Time within RF slice

SPE Response

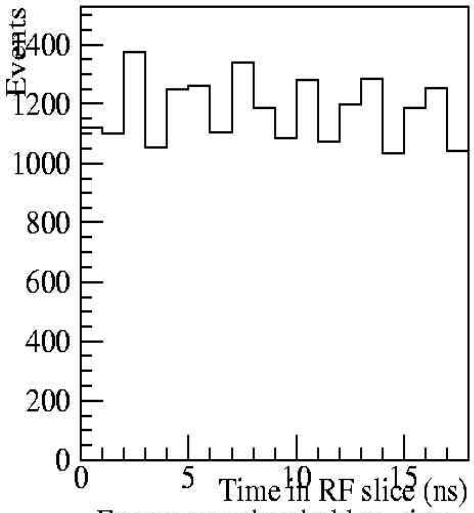
Gain ≈8×10^5

$\langle N_{pe} \rangle \approx 0.6$

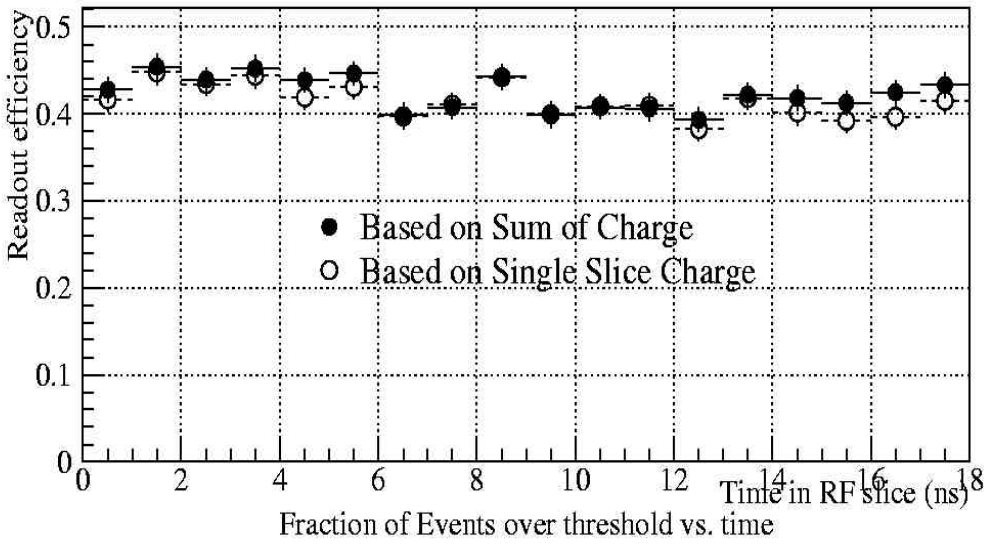
Lower gain also seems fine, but laser noise in this test stand is an issue



Single PE Response



Events over threshold vs. time

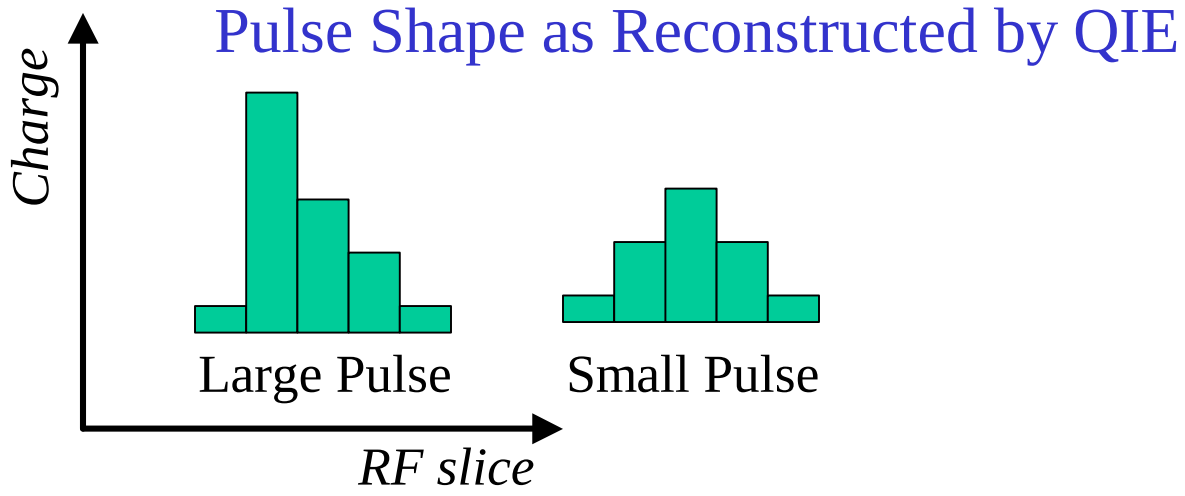


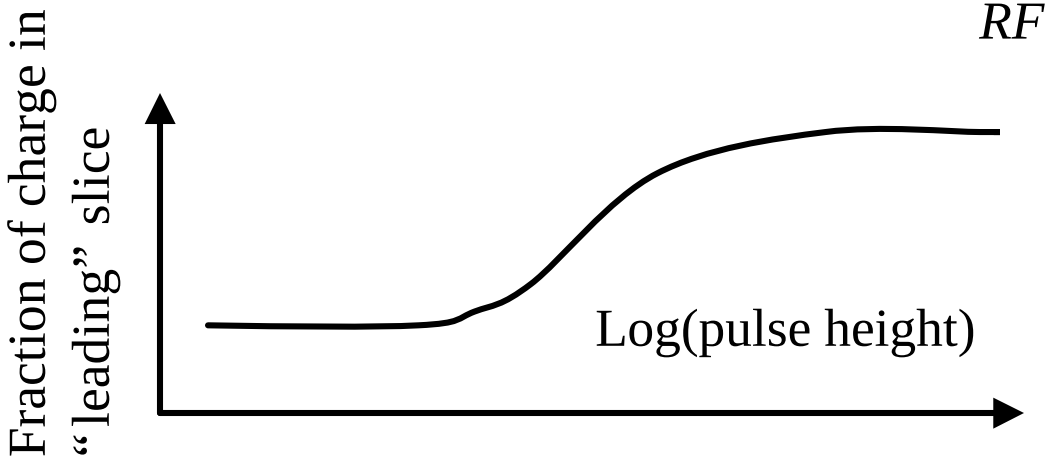
Fraction of Events over threshold vs. time

Fraction of events above threshold of $\langle Q_{pe} \rangle /3$ depends little on time in slice

Pulse Shape Distortion

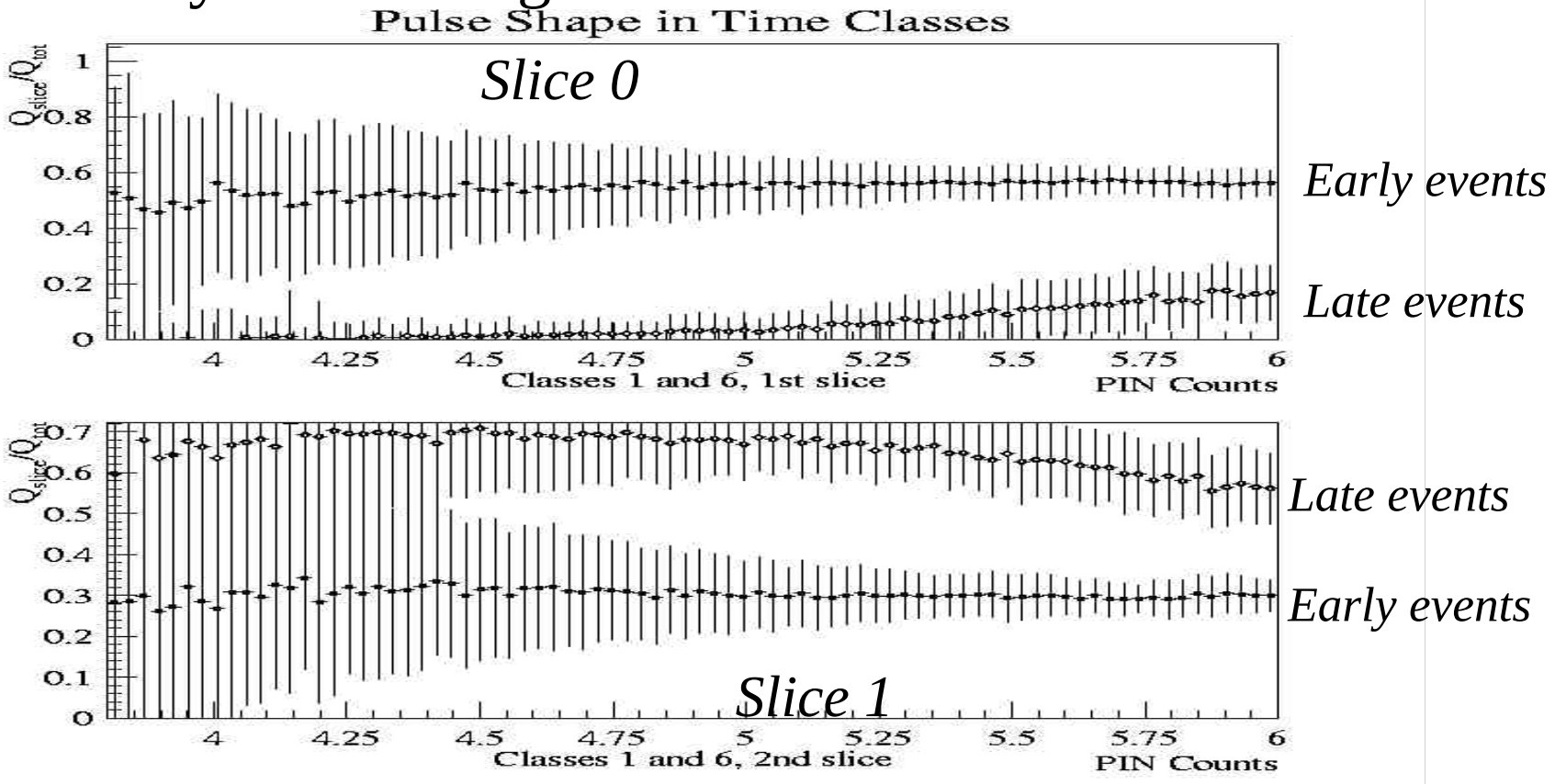
- Pre-MINOS QIEs input impedance changed with pulse height





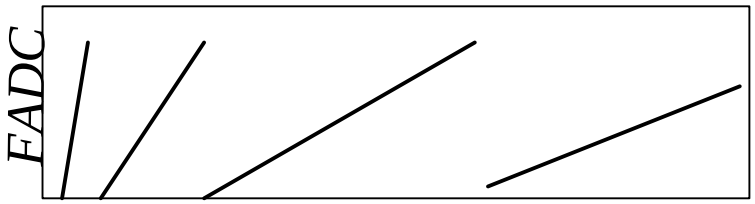
Pulse Shape Distortion

- Effect is minimal, especially within realistic Dynamic Range

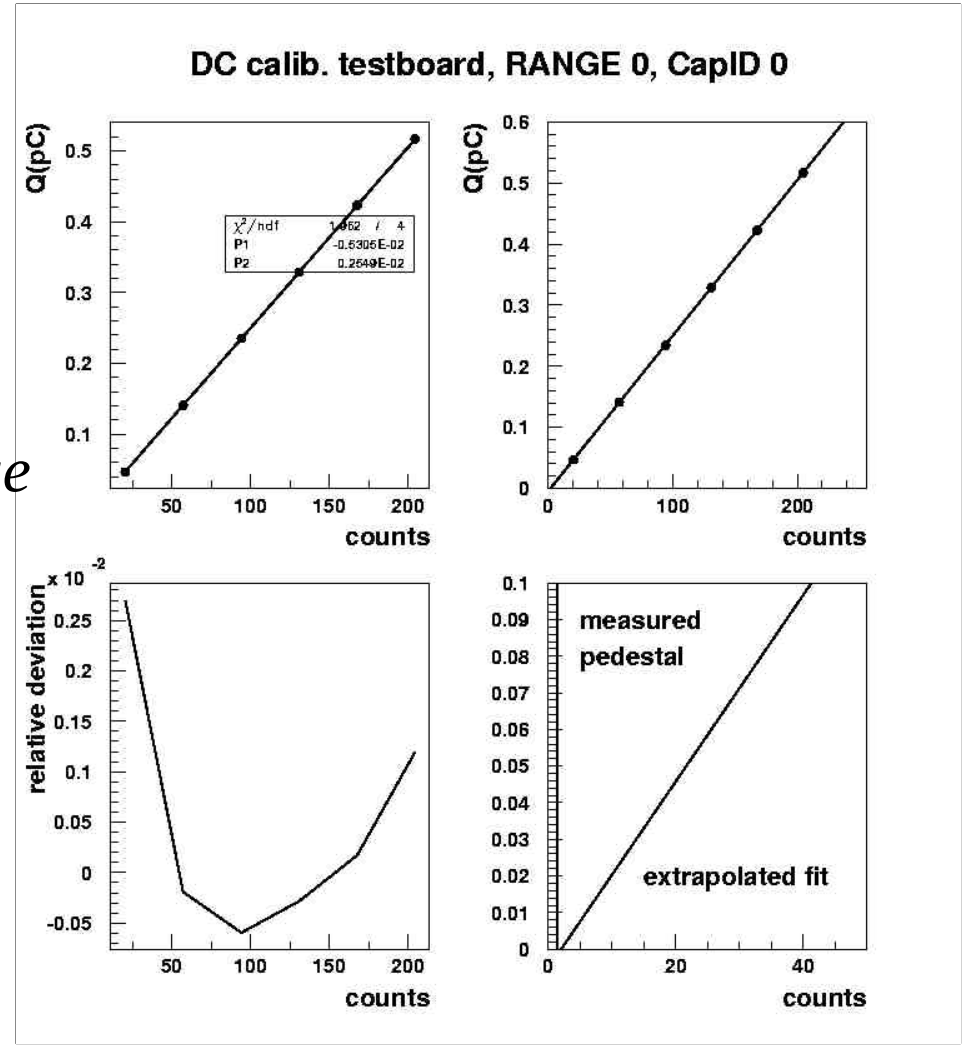


Calibration

- QIE response – 8 ranges, 4 CapIDs

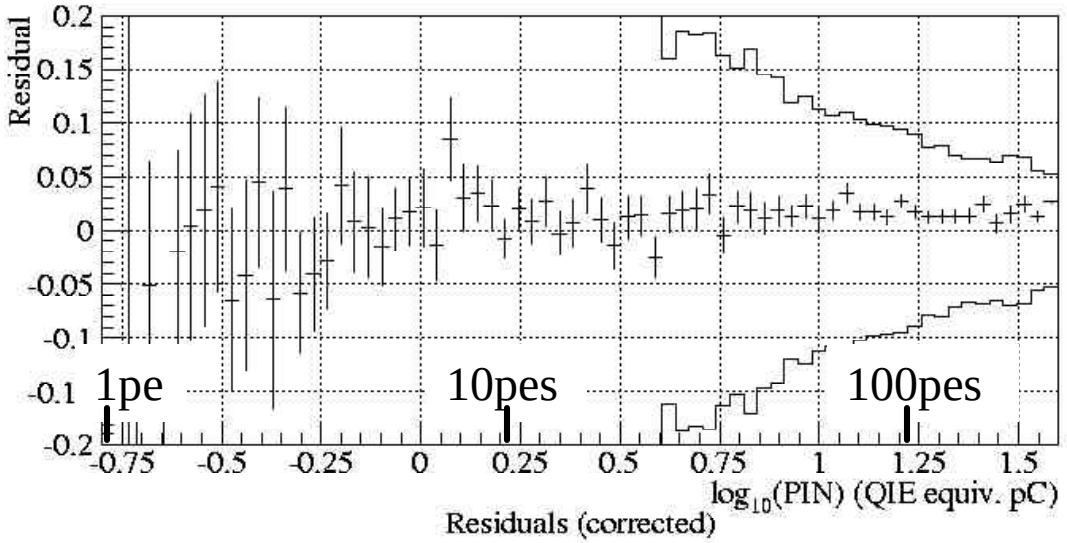


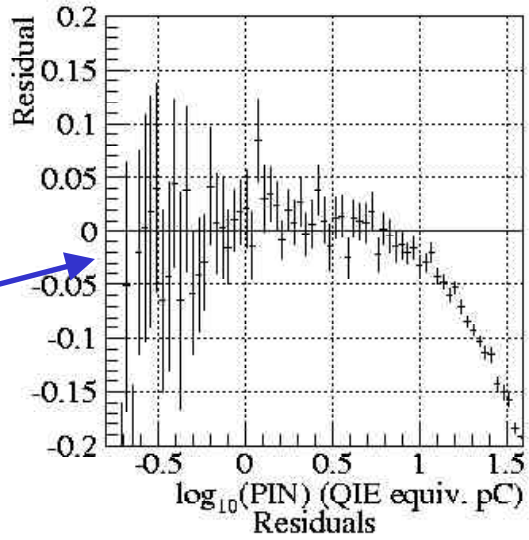
- DC current injection – find 32 slopes and 32 offsets (1 per range and CapID)



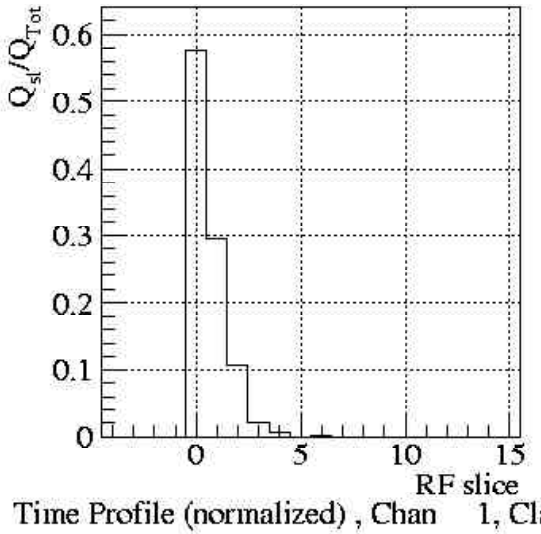
Linearity

- Scale PIN diode to small signal QIE response
- Calculate net residual
- Correct for PMT non-linearity measured with LRS 2249W ADC



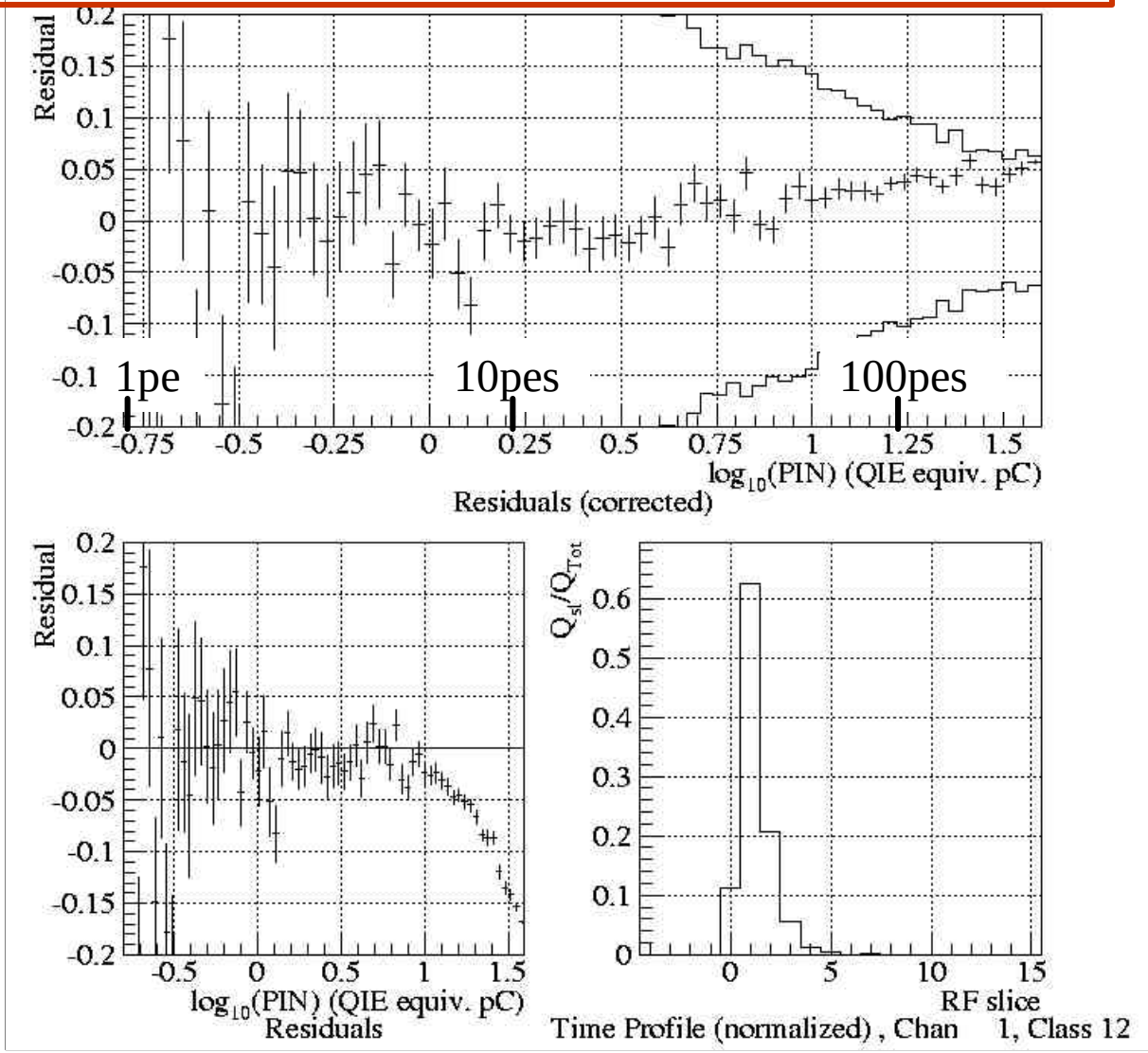


Uncorrected residuals



Linearity vs. Timing

- Events with rising edge near clock have noticeably worse linearity
- Still within spec.



Summary

- **QIE tests with realistic pulse shape at Lab5 at Fermilab**
  - **SPE response**
    - Uniform efficiency with respect to timing relative to RF clock
  - **Clock edge distortions**
    - <5% effects in response among different timings with respect to clock edge
  - **Impedance Issues**
    - Stable pulse shape
    - No significant reflections